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EXECUTIVE SUMMARY

MOE LEACHATE EXTRACTION PROCEDURE

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Chemical Research Department

To determine suitability of Ontario Hydro coal ash for use as backfill, representative multilevel samples of stockpiled ash were obtained from Lambton TGS (fly ash and bottom ash), Nanticoke TGS (fly ash) and Lakeview TGS (bottom ash). These samples were subjected to the Ontario Ministry of the Environment's Leachate Extraction Procedure. From detailed chemical analysis of the extracts, it was found that fly ash from both Lambton TGS and Nanticoke TGS were within the acceptable backfill guideline limits except only for selenium, which was slightly in excess for each. Bottom ash from Lambton TGS met the guideline, except for manganese and phenols in ash samples taken from the deeper strata. Lakeview TGS bottom ash met all leachate guideline criteria for backfill use. Candidate backfill material for a northern Ontario mine was prepared from crushed mine rock, Portland cement, and Thunder Bay TGS lignite fly ash. The resultant monolithic solid gave MOE leachate test results that showed the material to be non-hazardous and suitable for backfill use.

job	file	date	report no.
31-221-592	837.71	October 9, 1986	86-196-K

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To: Mr. D.K.A. Gillies
Manager
Environmental Protection
Central Thermal Services
Technical and Training Services Division

Attn: Dr. A.W. Jackson

MOE LEACHATE EXTRACTION PROCEDURE

A. Golomb

To assess suitability for backfill use, multilevel samples of coal ash were taken from stockpiles at Lambton TGS, Lakeview TGS and Nanticoke TGS. Each ash was subjected to the Ontario MOE Leachate Extraction Procedure and the aqueous extracts chemically analyzed. Lakeview TGS bottom ash met all leachate guideline criteria for backfill use. Bottom ash from Lambton TGS met all the guidelines except for manganese and phenols in ash taken from the deeper strata. Fly ash from Lambton TGS and from Nanticoke TGS met the backfill guideline except for selenium, which was slightly in excess for each. Candidate backfill for a mine in northern Ontario, containing Thunder Bay TGS lignite fly ash admixed with rock and Portland cement, yielded a MOE leachate that indicated the material to be non-hazardous and suitable for backfill use.

INTRODUCTION

To develop commercial markets for fly ash and bottom ash produced at Ontario Hydro's thermal generating stations, it is necessary to first generate leachate data for these materials so that they may be categorized in terms of current guidelines (Regulation 309) set forth by the Ontario Ministry of the Environment (MOE)/1,2,3/. In response to a request by Central Thermal Services, Chemical Research Department undertook to obtain and investigate the leaching characteristics of representative samples of stockpiled coal ash from Lambton TGS (fly ash and bottom ash), Nanticoke TGS (fly ash) and Lakeview TGS (bottom ash). In addition, it was agreed to carry out leachate testing

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of a candidate northern Ontario stope mining backfill material composed of a blend of crushed rock from Kidd Creek Mines with Portland Cement and Thunder Bay lignite fly ash.

The MOE Leachate Extraction Procedure issued in October, 1984/2/, was used. (This method has since been formally revised/3/, in November, 1985, with only a few minor modifications).

EXPERIMENTAL

Representative samples were taken of stockpiled coal ash (3 strata for each: shallow, intermediate and deep as measured from the top) from Lambton TGS (fly ash and bottom ash), Nanticoke TGS (fly ash), and Lakeview TGS (bottom ash). Sampling was carried out by personnel from Civil Research Department, using a locally-rented drilling rig at each station. Figures 1-4 illustrate plan views of the various sampling locations at each stockpile. Figures 5-8 show cross-sectional elevations.

To determine suitability for backfill use, a representative composite sample of each ash stratum (shallow, intermediate and deep) was subjected to the MOE Leachate Extraction Procedure (monofill/anaerobic conditions/1,2/). This entailed tumbling one part by weight of ash (dry basis) with twenty parts by weight of deionized water as extractant for 24 h under nitrogen at a rotational speed of 10 rpm. The extracts were filtered through 0.45μm Millipore filters and chemically analyzed for species of concern.

RESULTS AND DISCUSSION FOR COAL ASHES

Analytical results are given in Tables I-IV. The last column in each Table gives maximum acceptable extract concentrations for backfill use: these limits were derived/4/ from the revised (1983) Ontario Drinking Water Objectives/5/ as follows:

(i) 1 times the maximum health-related Objectives, and

(ii) 5 times the maximum aesthetic quality-related objectives.

For comparison, a shake test extraction was carried out for three of the shallow coal ash samples; results of these extractions are given in parenthesis. Results of tumble tests and shake tests were found to be in excellent agreement.

Using the monofill/anaerobic technique (ie no pH adjustment) acceptability for backfill use was assessed as follows:

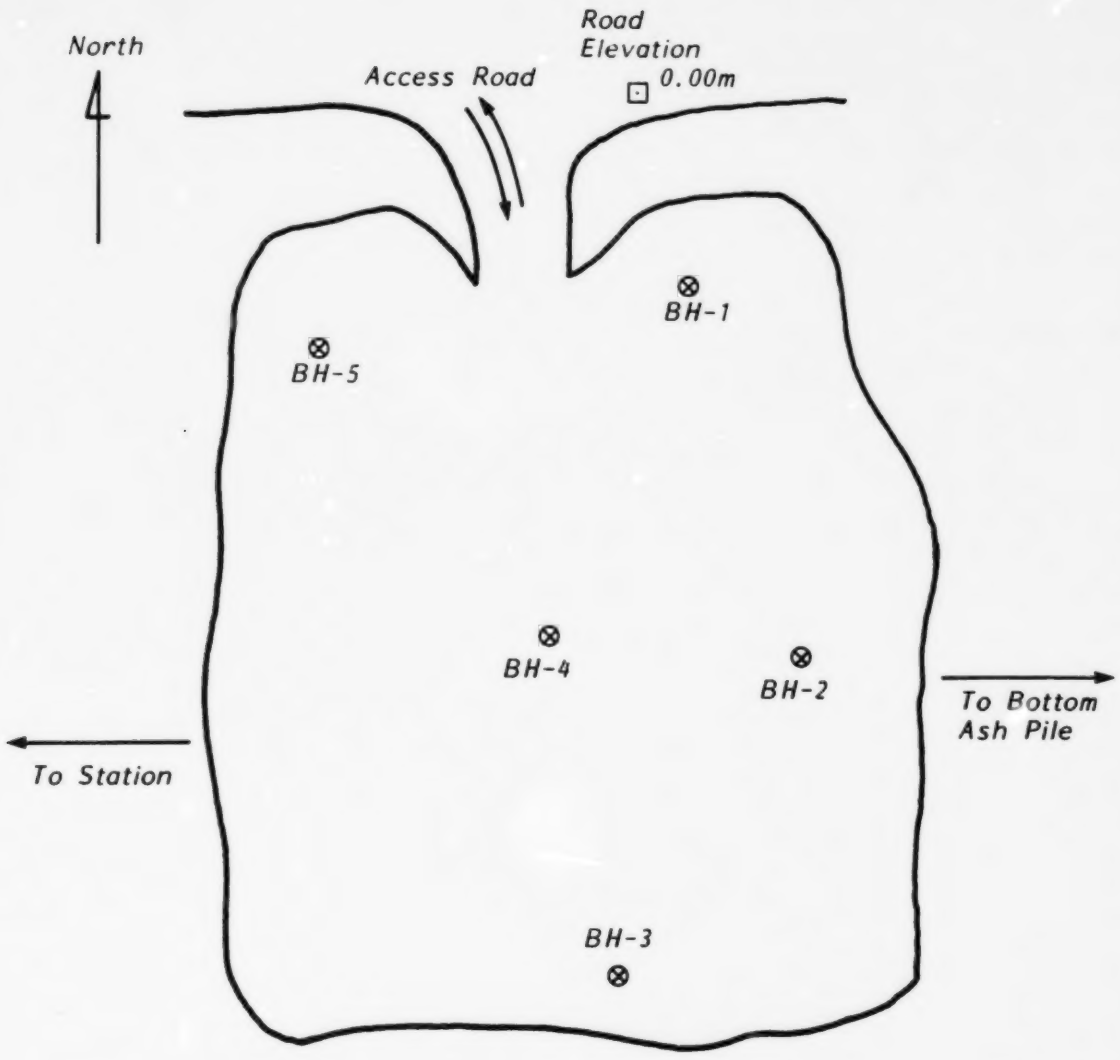


FIGURE 1

PLAN VIEW OF FLY ASH STOCKPILE, LAMBTON TGS (NOT TO SCALE)

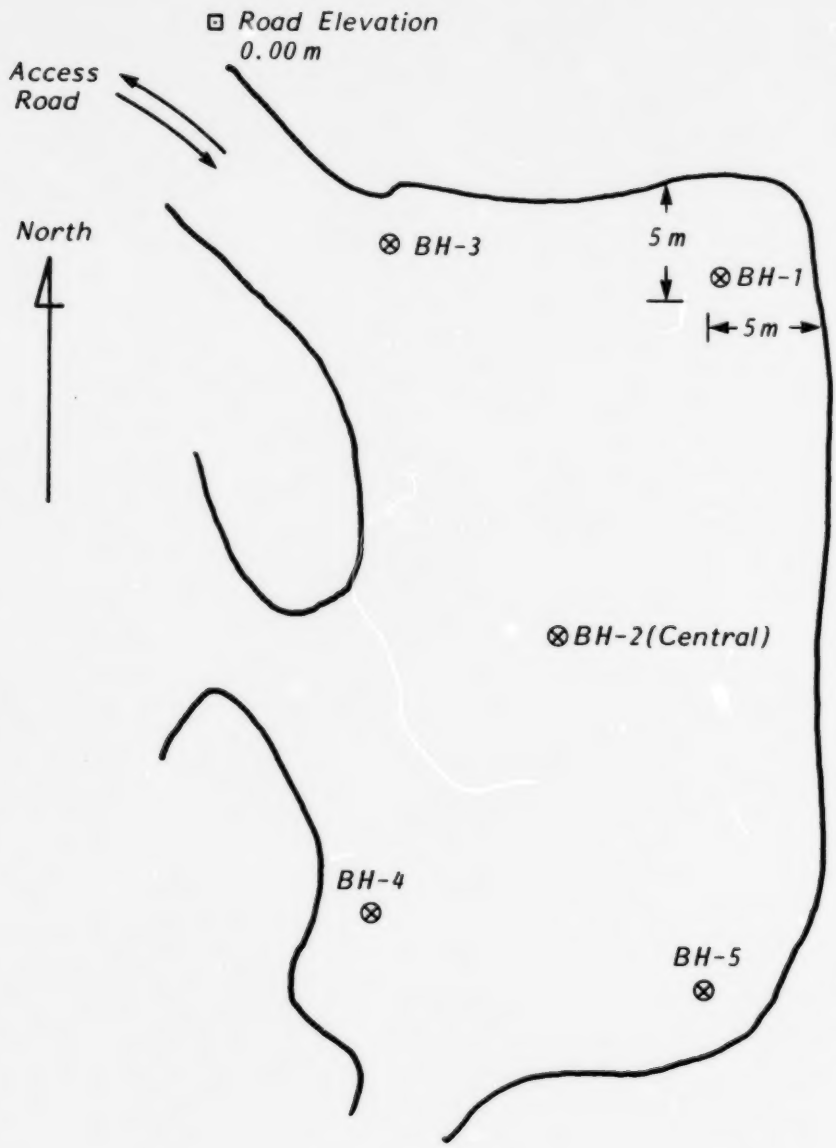


FIGURE 2

PLAN VIEW OF BOTTOM ASH STOCKPILE, LAMBTON TGS (NOT TO SCALE)

171834 RD

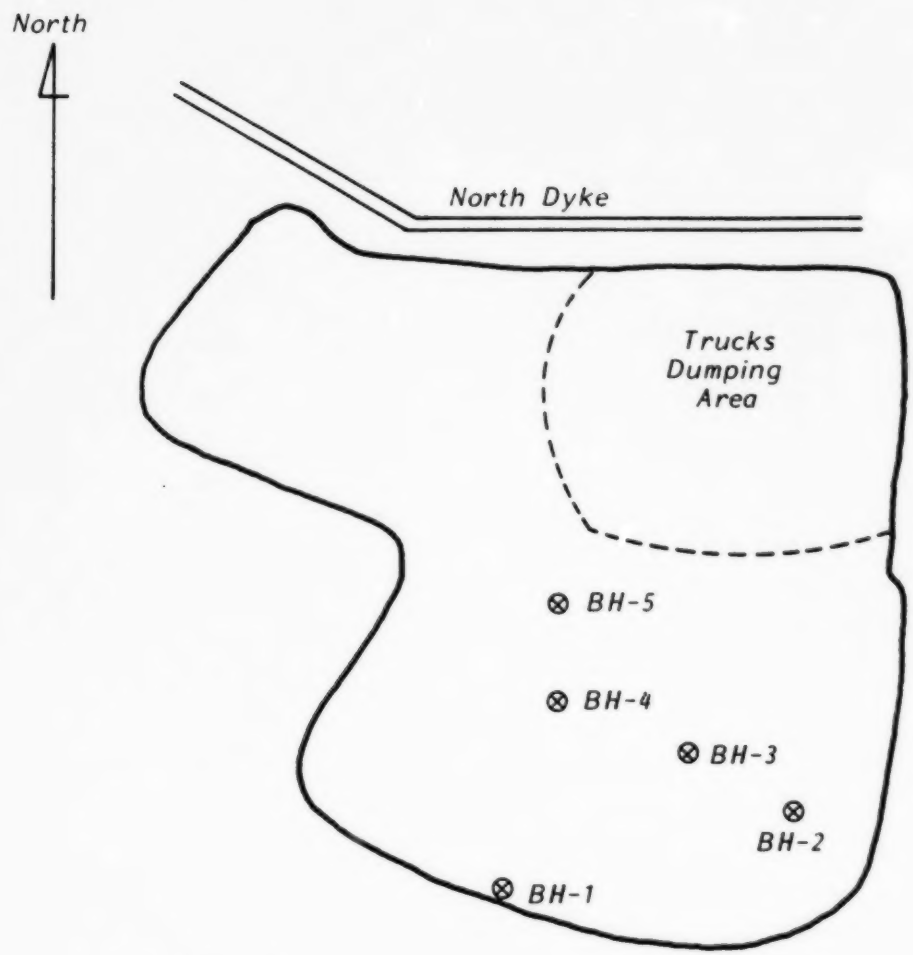
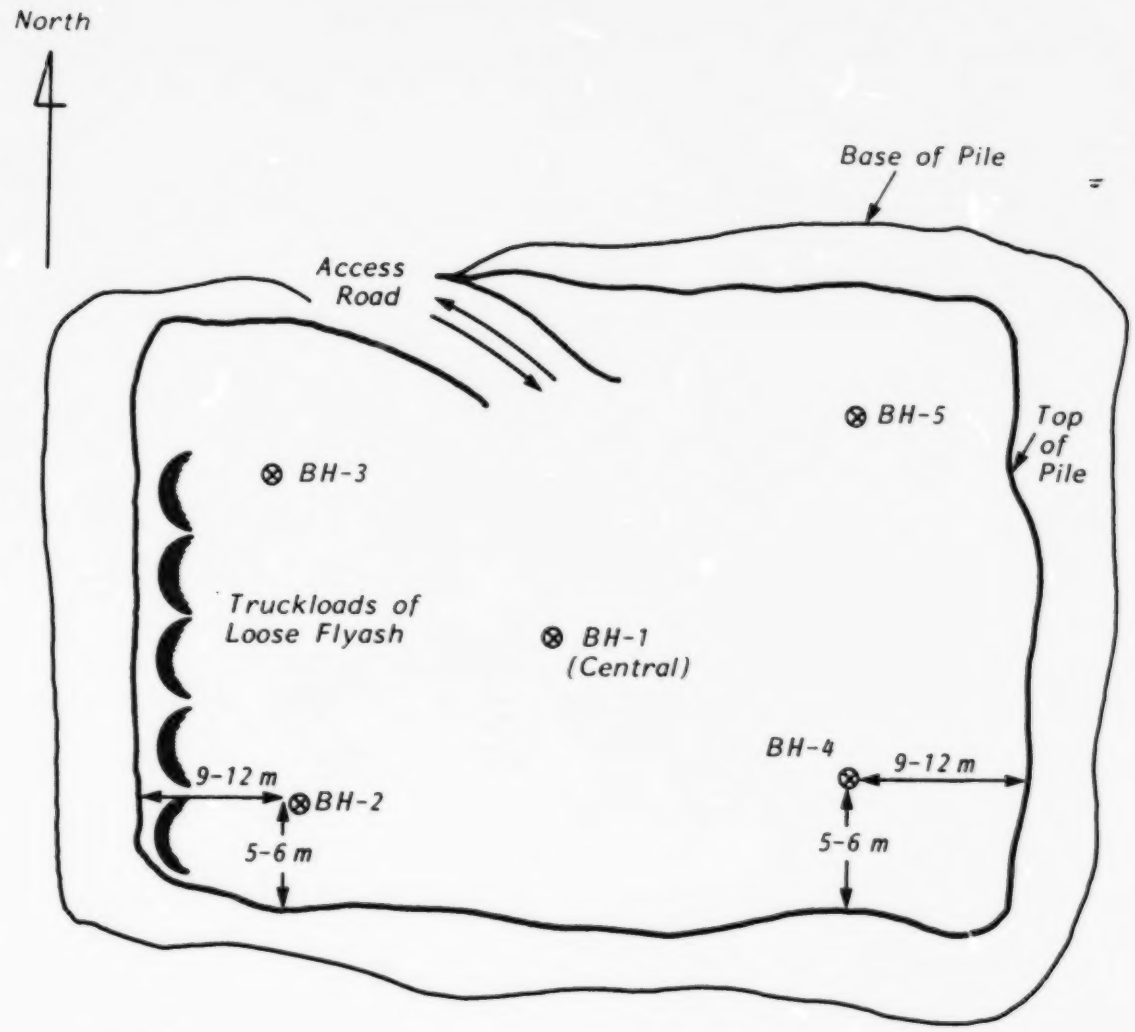


FIGURE 3

PLAN VIEW OF FLY ASH STOCKPILE, NANTICOKE TGS
(NOT TO SCALE) MAY 8, 1984

171835 RD



Legend:

⊗ Sampling Borehole Location

FIGURE 4

PLAN VIEW OF BOTTOM ASH STOCKPILE
LAKEVIEW TGS (NOT TO SCALE)

171836 RD

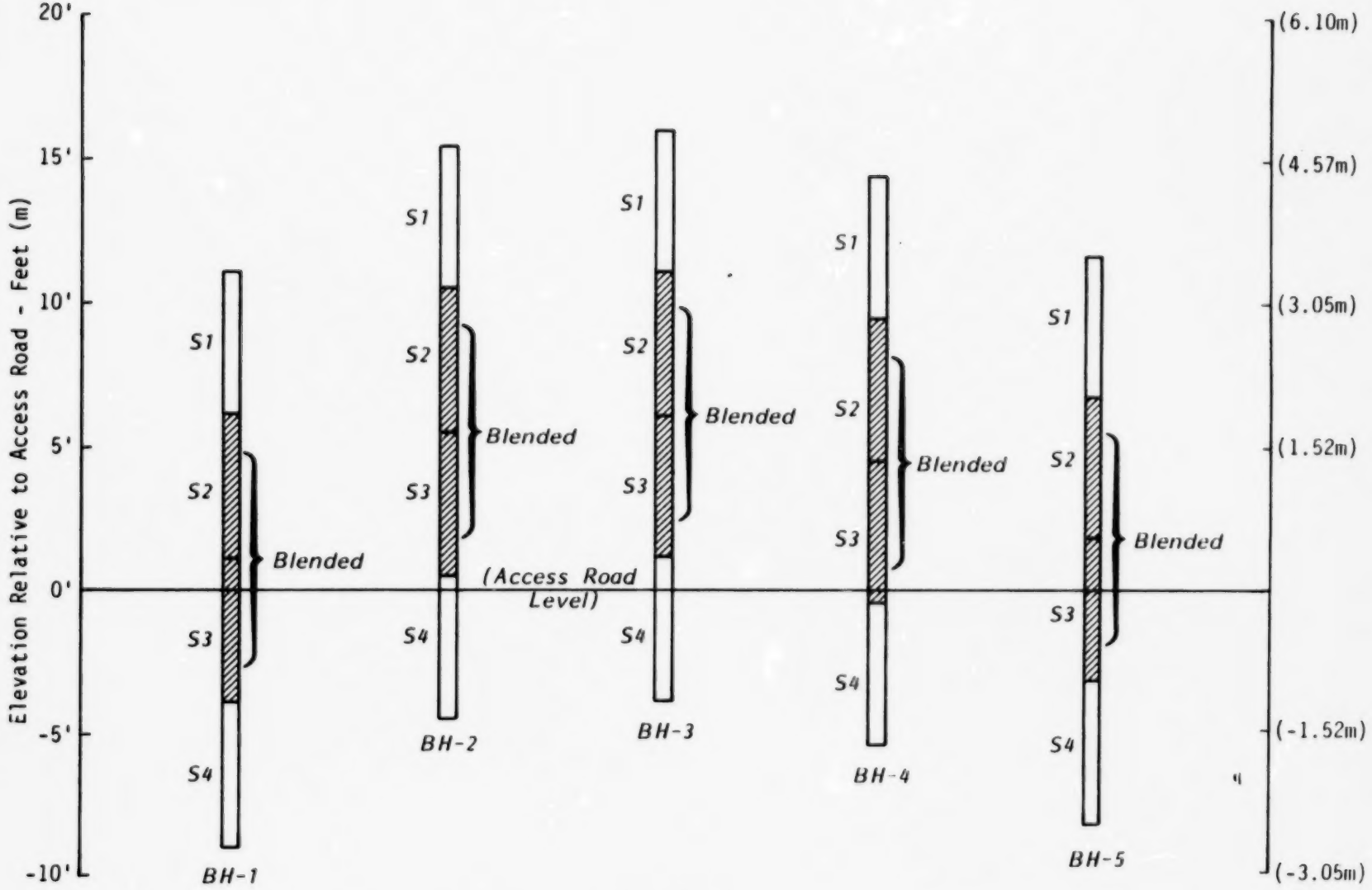


FIGURE 5

LAMBTON TGS - RELATIVE ELEVATIONS OF FLY ASH SAMPLES

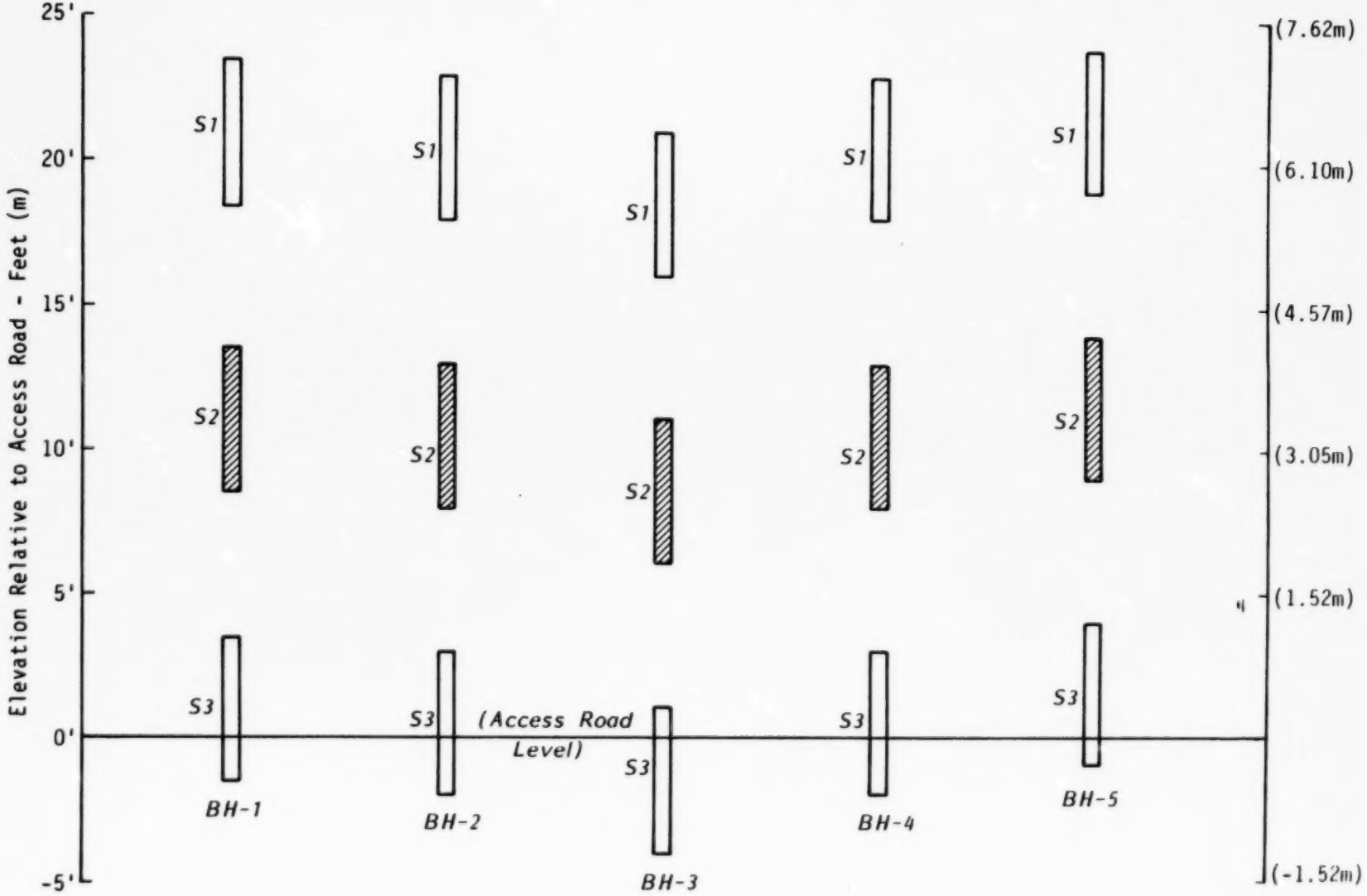


FIGURE 6

LAMBTON TGS - RELATIVE ELEVATIONS OF BOTTOM ASH SAMPLES

171838 RD

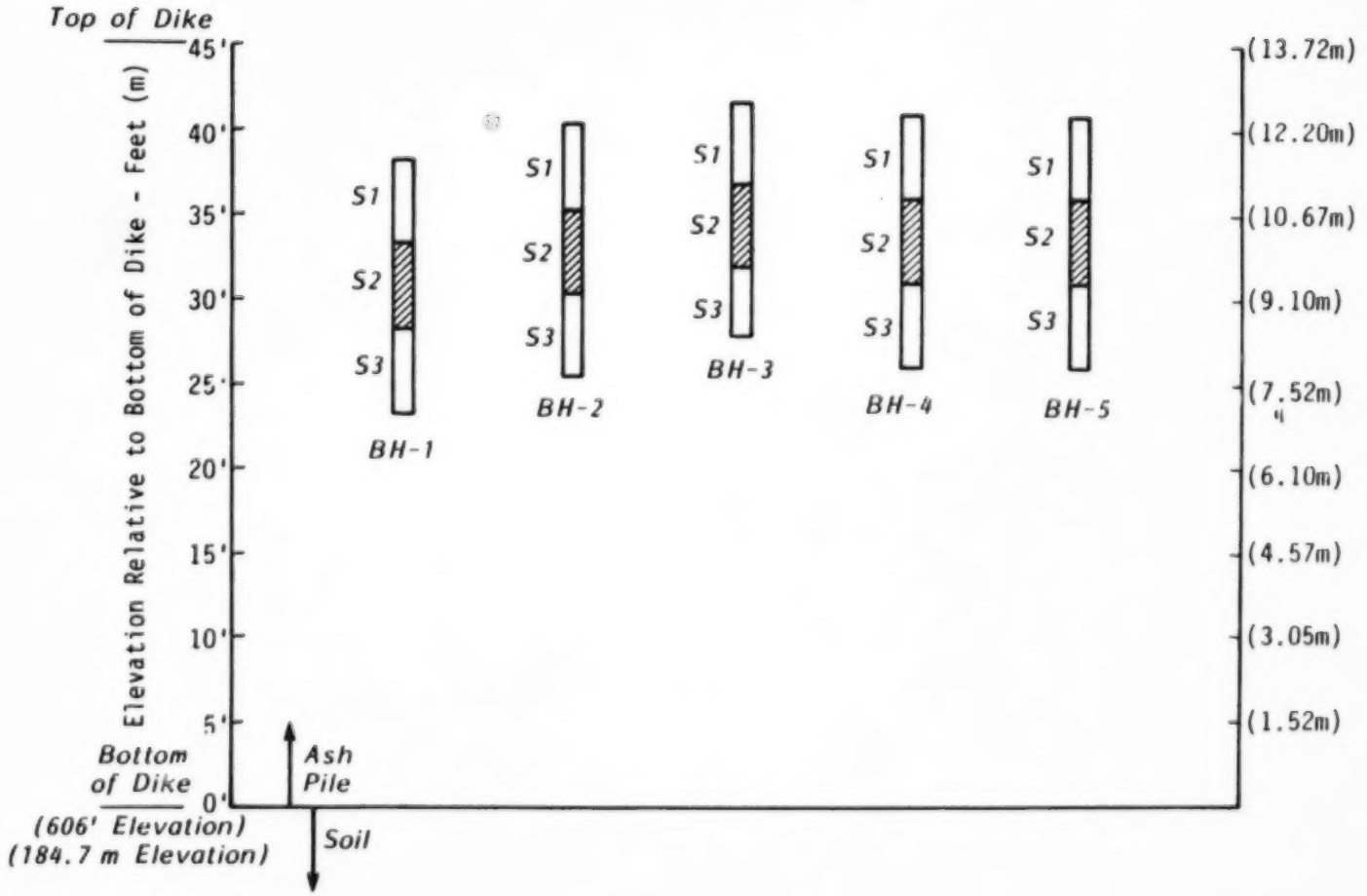


FIGURE 7

NANTICOKE TGS - RELATIVE ELEVATIONS OF FLY ASH SAMPLES

171839 RD

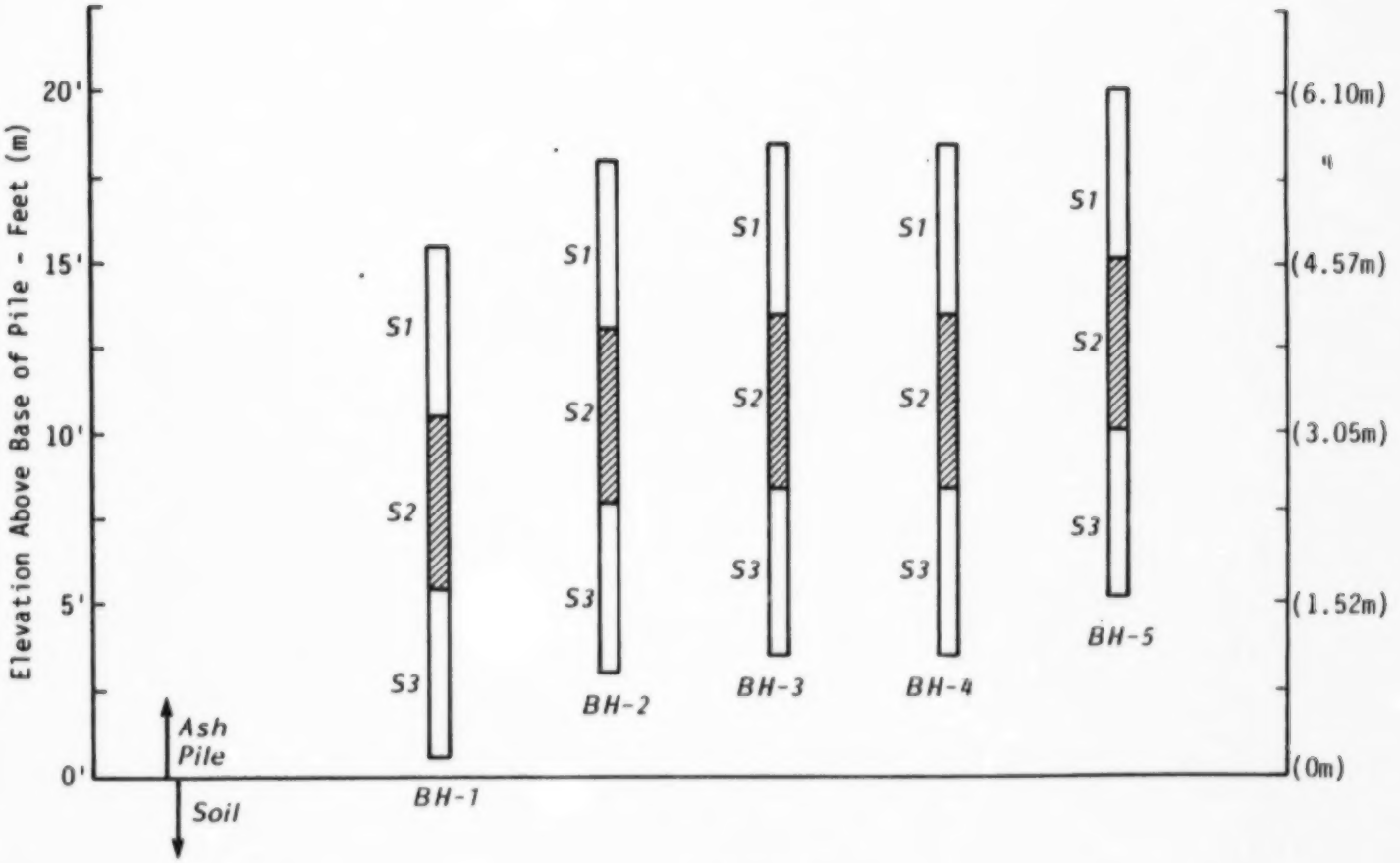


FIGURE 8

LAKEVIEW TGS - RELATIVE ELEVATIONS OF BOTTOM ASH SAMPLES

171840 RD

TABLE I

LAMBTON TGS FLY ASH STOCKPILE:
MOE LEACHATE EXTRACTION MONOFILL TUMBLE TEST/1,2/.

Parameter \ Stratum Sampled	Shallow	Intermediate	Deep	Maximum Acceptable Extract Concentration/4/ For BackFill Use
pH	10.1 (10.7)	9.9	9.5	-
Conductivity (mS/m)	53 (52.0)	61	82.5	-
As	0.01 (0.01)	0.012	0.014	0.05
Ba	<1 (<1)	<1	<1	1.0
B	2.4 (2.6)	3.0	3.4	5.0
Cd	<0.0001 (<0.0001)	0.0001	0.0001	0.005
Cr(total)	<0.05 (<0.1)	<0.05	<0.05	0.05
'WAD' CN	<0.04 (<0.04)	0.04	0.04	0.2
F^-	0.10 (0.13)	0.10	0.30	2.4
Pb	<0.002 (<0.002)	<0.002	<0.002	0.05
Hg	<0.0002 (<0.0002)	<0.0002	<0.0002	0.001
NO_3^- (as N)	0.009 (0.01)	0.031	0.008	10.0
NO_2^- (as N)	0.004 (0.008)	0.003	0.008	1.0
Total $[NO_3^- + NO_2^-]$(as N)	0.013 (0.018)	0.034	0.016	10.0
U	<0.01 (0.02)	<0.01	<0.01	0.02
PCBs	<0.001 (<0.0002)	<0.001	<0.001	0.003
Ra-226	<0.1 (0.16) pCi/L	<0.1 pCi/L	<0.1 pCi/L	3 pCi/L
Se	0.015 (0.016)	0.020	0.015	0.01
Ag	<0.0002 (<0.0002)	<0.0002	<0.0002	0.05
Cl^-	3.8 (3.8)	2.0	0.83	1250
Cu	<0.001 (<0.001)	<0.001	<0.001	5.0
Fe	<0.05 (<0.05)	<0.05	<0.05	1.5
Mn	<0.05 (<0.05)	<0.05	<0.05	0.25
Organic N	0.09 (0.06)	0.09	0.06	0.75
Phenols	<0.001 (<0.001)	<0.001	<0.001	0.01
$SO_4^=$	155 (160)	250	405	2500
TDS(105°C)	328 (338)	442	640	2500
TOC	6 (3)	4	4	25.0
Zn	<0.02 (<0.02)	<0.02	<0.02	25.0

Note: Concentrations given in mg/L except for Ra-226 (pCi/L).
(Data in parenthesis are for shake tests carried out for comparison).

TABLE II

LAMBTON TGS BOTTOM ASH STOCKPILE:
MOE LEACHATE EXTRACTION MONOFILL TUMBLE TEST/1,2/.

Parameter \ Stratum Sampled	Shallow	Intermediate	Deep	Maximum Acceptable Extract Concentration/4/ For BackFill Use
pH	8.5 (7.7)	4.3	4.1	-
Conductivity (mS/m)	19.5 (18.0)	73	121	-
As	0.002 (0.003)	<0.001	<0.001	0.05
Ba	<1 (<1)	<1	<1	1.0
B	0.12 (0.25)	0.30	0.48	5.0
Cd	<0.0001 (<0.0001)	0.0001	0.0003	0.005
Cr(total)	<0.05 (<0.1)	<0.05	<0.05	0.05
'WAD' CN	<0.04 (<0.04)	<0.04	<0.04	0.2
F^-	0.05 (0.03)	0.3	0.8	2.4
Pb	<0.002 (<0.002)	<0.002	<0.002	0.05
Hg	<0.0002 (0.0002)	<0.0002	<0.0002	0.001
NO_3^- (as N)	<0.002 (<0.010)	<0.002	<0.002	10.0
NO_2^- (as N)	<0.002 (0.006)	<0.002	<0.002	1.0
Total $[NO_3^- + NO_2^-]$(as N)	<0.004 (<0.016)	<0.004	<0.004	10.0
U	<0.01 (<0.01)	<0.01	<0.01	0.02
PCBs	<0.001 (<0.0002)	<0.001	<0.001	0.003
Ra-226	<0.1 (<0.1) pCi/L	0.69 pCi/L	<0.1 pCi/L	3 pCi/L
Se	0.001 (0.001)	0.001	0.002	0.01
Ag	<0.0002 (<0.0002)	<0.0002	<0.0002	0.05
Cl^-	2.8 (2.0)	0.17	0.17	1250
Cu	<0.001 (0.003)	0.035	0.048	5.0
Fe	<0.05 (<0.05)	0.05	0.40	1.5
Mn	<0.05 (<0.05)	0.64	0.85	0.25
Organic N	0.06 (0.09)	0.06	0.09	0.75
Phenols	0.003 (<0.001)	0.003	0.018	0.01
$SO_4^=$	64 (72.6)	400	735	2500
TDS(105°C)	103 (136)	580	1070	2500
TOC	4 (2)	3	<1	25.0
Zn	<0.02 (<0.02)	0.07	0.20	25.0

Note: Concentrations given in mg/L except for Ra-226 (pCi/L).
(Data in parenthesis are for shake tests carried out for comparison).

TABLE III

NANTICOKE TGS FLY ASH STOCKPILE:
MOE LEACHATE EXTRACTION MONOFILL TUMBLE TEST/1,2/.

Parameter / Stratum Sampled	Shallow	Intermediate	Deep	Maximum Acceptable Extract Concentration/4/ For BackFill Use
pH	10.8 (10.9)	10.7	10.7	-
Conductivity (mS/m)	26 (28.2)	36.5	35.7	-
As	0.026 (0.033)	0.023	0.030	0.05
Ba	<1 (<1)	<1	<1	1.0
B	1.9 (1.7)	1.5	1.4	5.0
Cd	<0.0001 (<0.0001)	<0.0001	<0.0001	0.005
Cr(total)	<0.05 (<0.1)	<0.05	<0.05	0.05
'WAD' CN	<0.04 (<0.04)	<0.04	<0.04	0.2
F^-	0.25 (0.07)	<0.02	0.15	2.4
Pb	<0.0002 (<0.0002)	<0.002	<0.002	0.05
Hg	<0.0002 (<0.0002)	<0.0002	<0.0002	0.001
NO_3^- (as N)	<0.005 (<0.01)	<0.005	<0.005	10.0
NO_2^- (as N)	<0.005 (<0.006)	<0.005	0.009	1.0
Total $[NO_3^- + NO_2^-]$(as N)	<0.01 (<0.016)	<0.01	<0.014	10.0
U	<0.01 (<0.01)	<0.01	<0.01	0.02
PCBs	<0.0001 (<0.0002)	<0.0001	<0.0001	0.003 L
Ra-226	<0.1 (0.14) pCi/L	<0.1 pCi/L	<0.1 pCi/L	3 pCi/
Se	0.035 (0.025)	0.019	0.029	0.01
Ag	<0.0002 (<0.0002)	<0.0002	<0.0002	0.05
Cl^-	0.55 (0.5)	0.8	1.5	1250
Cu	<0.001 (0.003)	<0.001	<0.001	5.0
Fe	<0.05 (<0.05)	<0.05	<0.05	1.5
Mn	<0.05 (<0.05)	<0.05	<0.05	0.25
Organic N	0.33 (0.06)	<0.03	0.18	0.75
Phenols	<0.001 (<0.001)	<0.001	<0.001	0.01
$SO_4^=$	40 (36)	41	45	2500
TDS(105°C)	150 (160)	190	225	2500
TOC	<1 (2)	<1	<1	25.0
Zn	<0.02 (<0.02)	<0.02	<0.02	25.0

Note: Concentrations given in mg/L except for Ra-226 (pCi/L).
(Data in parenthesis are for shake tests carried out for comparison.

TABLE IV

LAKEVIEW TGS BOTTOM ASH STOCKPILE:
MOE LEACHATE EXTRACTION MONOFILL TUMBLE TEST/1,2/.

Stratum Sampled / Parameter	Shallow	Intermediate	Deep	Maximum Acceptable Extract Concentration/4/ For BackFill Use
pH	8.9	8.0	7.3	-
Conductivity (mS/m)	10.4	21.8	33.0	-
As	0.004	<0.001	<0.001	0.05
Ba	<1	<1	<1	1.0
B	<0.05	0.08	0.12	5.0
Cd	<0.0001	<0.0001	<0.0001	0.005
Cr(total)	<0.05	<0.05	<0.05	0.05
'WAD' CN	<0.04	<0.04	<0.04	0.2
F^-	0.05	0.05	0.05	2.4
Pb	<0.002	<0.002	<0.002	0.05
Hg	<0.0002	<0.0002	<0.0002	0.001
NO_3^- (as N)	<0.002	<0.002	0.004	10.0
NO_2^- (as N)	<0.002	<0.002	<0.002	1.0
Total [NO_3^-+ NO_2^-](as N)	<0.004	<0.004	<0.006	10.0
U	0.01	<0.01	<0.01	0.02
PCBs	<0.0002	<0.001	<0.001	0.003
Ra-226	<0.1 pCi/L	<0.1 pCi/L	<0.1 pCi/L	3 pCi/L
Se	<0.001	<0.001	<0.001	0.01
Ag	<0.0002	<0.0002	<0.0002	0.05
Cl^-	0.28	0.44	0.24	1250
Cu	<0.001	<0.001	<0.001	5.0
Fe	<0.05	<0.05	<0.05	1.5
Mn	<0.05	<0.05	<0.05	0.25
Organic N	0.06	0.06	0.06	0.75
Phenols	0.002	<0.001	<0.001	0.01
$SO_4^=$	29	85	150	2500
TDS(105°C)	69	143	231	2500
TOC	3	2	1	25.0
Zn	<0.02	<0.02	<0.02	25.0

Note: Concentrations given in mg/L except for Ra-226 (pCi/L).

(a) Lambton TGS fly ash (Table I)
Generally acceptable, although selenium was marginally above the backfill extract guideline limit of 0.01 mg/L.

(b) Lambton TGS bottom ash (Table II)
Generally acceptable for backfill, although manganese, below the limit on the shallow sample, was excessive in the intermediate and deep samples. Phenols were marginally excessive in the deep sample only.

(c) Nanticoke TGS fly ash (Table III)
All species were within acceptable extract concentration limits except for selenium, which was marginally excessive.

(d) Lakeview TGS bottom ash (Table IV)
Acceptable as backfill in terms of all extract parameters. The Credit Valley Conservation Authority has expressed interest in utilizing all bottom ash produced at Lakeview TGS/6/ over the next 5 years or so, for road and pathway construction at the A.E. Crookes Park development near Lakeview TGS. From the standpoint of leachate sensitivity, Lakeview bottom ash meets the required guidelines.

Thunder Bay TGS Lignite Ash for Use in Mining Backfill

Kidd Creek Mines currently use stope mining techniques in their zinc, copper, lead and silver operations near Timmins, northern Ontario/6/. As of 1983, ore output was 4.5 million tonnes annually. Vaults formed by the stopes and pillars have hitherto been backfilled with a mixture containing graded aggregate, Portland Cement, and sometimes sand as a void filler. In view of the large tonnages of pozzolanic lignite fly ash expected to be generated at Thunder Bay TGS, it was considered worthwhile to investigate the possibility of replacing at least part of the Portland cement with lignite ash. A sample of crushed rock aggregate obtained from Kidd Creek Mines was blended with No 10 Portland cement, Thunder Bay lignite fly ash and water in the following proportions to simulate the proposed backfill material:

	Total Weight %	Weight (%) Dry Solid Basis
Crushed rock (passing #4 mesh ASTM sieve)	79.3	95
Portland cement (passing #10 mesh ASTM sieve)	1.7	2
Thunder Bay TGS lignite fly ash	2.5	3
Water (to form cement-like paste)	16.5	-
TOTAL	100.0	100

Three-fifths of the Portland cement, which normally constitutes 5% w/w of the backfill solids, was replaced by lignite fly ash. The amount of water added was the minimum necessary to allow the mixture to be cast into standard moulds, as prescribed in the MOE's test protocol/1,2/ to determine the structural integrity of the cured specimen prior to leachate extraction. Six standard mould castings were allowed to set for 28 days at 100% relative humidity (22°C) in a curing chamber. Four of these specimens survived the MOE structural integrity test intact, and the cured material was subsequently extracted as a monolith.

The candidate backfill material was subjected to both the mono-fill and the co-disposal anaerobic leaching test; analytical results for the resultant extracts are given in Table V.

From Table V, it is evident that the candidate backfill material containing Thunder Bay TGS fly ash is non-hazardous and meets the leaching criteria for use as backfill.

CONCLUSIONS

From the results of MOE leachate extraction tests (Regulation 309) carried out on representative multilevel ash samples taken from stockpiles at Lakeview TGS, Nanticoke TGS and Lambton TGS, the following conclusions are drawn:

(i) All of the ashes are non-hazardous, ie they are non-"leachate toxic".

(ii) Fly ash from both Lambton TGS and Nanticoke TGS falls within the MOE backfill guidelines, except for selenium, which is slightly in excess for each.

(iii) Bottom ash from Lambton TGS falls within the backfill guideline, except for manganese and phenols in samples taken from the deeper strata.

(iv) Bottom ash from Lakeview TGS meets all of the leachate criteria for backfill use.

TABLE V

THUNDER BAY TGS FLY ASH/ROCK/CEMENT:
MOE LEACHATE EXTRACTION CO-DISPOSAL AND MONOFILL TUMBLE TEST/1,2/.

Parameter	Codisposal (Anaerobic)	Maximum Acceptable Extract Concentration/4/ For Hazardous Waste Categorization	Monofill (Anaerobic)	Maximum Acceptable Extract Concentration/4/ For Backfill Use
pH	5.2	-	10.1	-
Conductivity (mS/m)	NA	-	44.0	-
As	<0.001	5.0	<0.001	0.05
Ba	<1	100	<1	1.0
B	2.7	500	5.0	5.0
Cd	0.35	0.5	<0.0001	0.005
Cr(total)	<0.05	5.0	<0.05	0.05
'WAD' CN	<0.04	20	<0.04	0.2
F^-	0.9	240	1.9	2.4
Pb	1.0	-	<0.002	0.05
Hg	<0.0002	0.1	<0.0002	0.001
NO_3^- (as N)	0.08	1000	0.16	10.0
NO_2^- (as N)	0.02	100	0.04	1.0
Total $[NO_3^- + NO_2^-]$(as N)	0.10	1100	0.20	10.0
U	<0.01	2.0	<0.01	0.02
PCBs	<0.0002	0.3	<0.0002	0.003
Ra-226	<0.1 pCi/L	300 pCi/L	<0.1 pCi/L	3 pCi/L
Se	<0.001	1.0	<0.001	0.01
Ag	0.03	5.0	<0.025	0.05
Cl^-	1.2	-	2.1	1250
Cu	1.1	-	0.05	5.0
Fe	2.7	-	<0.05	1.5
Mn	8.2	-	<0.05	0.25
Organic N	0.18	-	0.18	0.75
Phenols	<0.001	-	<0.001	0.01
$SO_4^=$	276	-	300	2500
TDS(105°C)	NA	-	430	2500
TOC	NA	-	2	25.0
Zn	40	-	<0.02	25.0

Note: Concentrations given in mg/L except for Ra-226 (pCi/L).
NA denotes not not applicable due to acetic acid addition during extraction.

(v) Candidate backfill material for a northern Ontario Mine, prepared using Thunder Bay TGS fly ash as partial replacement for Portland cement, is non-hazardous and suitable for backfill use.

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AG:am

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